

Indoor Environmental Quality

A building's indoor environment is the result of a complex interaction between site, climate, building mechanical systems, contaminant sources and the building occupants. The goal of the Indoor Environmental Quality category in LEED is to provide a healthy, comfortable and productive indoor environment for building occupants. Creating and maintaining such an environment requires the successful integration of multiple design decisions and addressing such issues as adequate ventilation for occupants, off-gassing from finish materials and mechanical equipment, tobacco smoke, microbiological contamination and outside air pollutants.



Aspen Skiing Company – Snowmass Golf Clubhouse

Courtesy: Aspen Skiing Company

EQ Prerequisite 1: Minimum IAQ Performance

This prerequisite requires the designer to meet the minimum requirements of the ventilation standard: ASHRAE 62-1999 and approved addenda, with a reference to ASHRAE 62-2001 Appendix H. ASHRAE 62-1999 sets contaminant standards for indoor environmental quality. Standard mechanical design practices in Colorado generally promote compliance with ASHRAE 62-1999.

ASHRAE 62-2004 is an acceptable threshold for compliance as well. If, however, ASHRAE 62.1-2004 is used to demonstrate compliance with the prerequisite, it must also be used in calculations applied to EQc1.

Recommendation:

- Engineers should confirm that the project meets the minimum requirements of ASHRAE 62-1999 upfront and early in design.

Helpful Hints:

- Ventilation systems may be mechanical or natural. If natural ventilation and infiltration are being used, compliance with ASHRAE 62-1999 can be demonstrated using a tracer gas test (described in ASHRAE 55-1999) or by performing calculations of natural ventilation based on wind pressure and thermal buoyancy (stack-effect) driven ventilation as described in the ASHRAE Handbook of Fundamentals, Chapter 22 or the ASHRAE Standard 62-2001.
- ASHRAE 62.1-2004 combines Standard 62-2001 and published addenda, thereby providing an easy-to-use consolidated standard. Standard 62.1-2004 specifies minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects.

QUICK FACTS

Implementation: Required.

Resources:

Referenced Standard: ASHRAE Standard 62-1999: Ventilation for Acceptable Indoor Air Quality

The ASHRAE reference standard is available at the ASHRAE website. Interpretations, approved addenda, and the recent versions (Standard 62-2001 and 2004) can also be accessed.

Website: www.ashrae.org

U.S. Environmental Protection Agency
Indoor Air Quality in Large Buildings

This resource includes publications, information and tools for indoor air quality assessment.

Website:

www.epa.gov/iaq/largebldgs/index.html

EQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

In March 2006, Colorado became the 13th state in the U.S. to adopt a statewide smoking ban. The law prohibits smoking in bars, restaurants, and most workplaces and takes effect July 1, 2006. Exemptions to the smoking ban include private homes; automobiles, if not used for child care or public transportation of children; privately hired limousines; as much as 25 percent of hotel and motel rooms; retail tobacco businesses; the outdoor area of any business; places of employment not open to the public with three or fewer employees; casinos; and Denver International Airport.

Thus, this prerequisite is not a given for all projects in Colorado. Residential applications can be especially difficult since it is necessary to accommodate and respect personal preference regarding smoking. LEED provides two ways to achieve this prerequisite: 1) prohibit smoking in the project facilities and designate exterior smoking areas away from main entrances/exits, or 2) provide negatively pressurized, fully enclosed designated smoking rooms in the building.

Recommendations:

- If the project includes smoking rooms, make sure the project budget/scope includes allotted fees and requirements for tracer gas testing.
- Many CIRs have been posted regarding residential applications and meeting LEED requirements through alternative compliance options. CIR 12/3/2003 addresses these options in detail.
- Designated exterior smoking areas should be shown on the site/civil or landscape furnishing plans. Avoid locating these areas near building entrances/exits.

QUICK FACTS

Implementation: Required.

Examples:

- Continuum Partners' Belmar Block 2 development project provided a signed letter template stating that smoking is prohibited inside project facilities. In addition, they provided an excerpt from the tenant guidelines outlining the building's non-smoking policy to the tenants, and a site plan highlighting designated smoking areas in the proper location.

Resources:

Referenced Standard: ASHRAE Standard 129-1997: Measuring Air-Change Effectiveness

ASHRAE Standard 129-1997 that describes the method to perform the tracer gas testing can be found on the ASHRAE website.

Website: www.ashrae.org

Colorado Clean Indoor Air Act

The statewide smoking ban was signed into law on March 26, 2006 and takes effect July 1, 2006.

Website:

www.state.co.us/gov_dir/leg_dir/olls/sl2006a/sl22.htm

Group to Alleviate Smoking Pollution

Provides details on smoking bans for individual cities and counties in Colorado.

Website:

www.gaspforair.org/gasp/ordinance/ordinance_index.php

American Lung Association

This article provides information on secondhand smoke, the effects and prevention.

Website:

www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=35421

EQ Credit 1: Carbon Dioxide (CO₂) Monitoring

The intent of this credit is to provide improved indoor air quality by addressing (minimizing) carbon dioxide levels in occupied spaces. Although higher ventilation rates may be required, carbon dioxide monitors act as surrogate occupancy sensors and only provide higher ventilation rates when required. In this way, energy savings can be realized by not over-ventilating a space during periods of intermittent or variable occupancy. In general, it is left to the discretion of the mechanical engineer to assure the design of the carbon dioxide monitoring system accurately reflects occupancy and demand ventilation levels. Residential applications have been able to meet the credit requirement through CO₂ monitoring in public or common areas and carbon monoxide monitors in areas near combustion equipment (See CIR 9/3/04).

Recommendation:

- Proper system design and CO₂ sensor placement is critical. Locating sensors only in densely occupied areas can unnecessarily drive ventilation systems. Similarly problematic is grouping spaces with dissimilar occupancy patterns.
- When used with demand controlled ventilation, properly placed CO₂ sensors can pay for themselves in three years or less, by limiting the amount of unnecessary outside air for ventilation.

Helpful Hints:

- Operational adjustment of building systems due to CO₂ monitor feedback can be interpreted as either automatic adjustment or manual adjustment.
- The CO₂ monitoring system does not require that sensors be located in every room, but rather are representative of appropriate areas or mechanical zones.

Examples:

- The Opus Northwest Department of Transportation building successfully achieved this credit by providing a signed letter template, a narrative and specifications describing the installation, operational design and controls/zones for the CO₂ monitoring system.

QUICK FACTS

Implementation: Recommended.

Historical Data: 50% of Colorado LEED certified projects have successfully earned this credit.



The North Boulder Recreation Center

CO₂ monitoring is most effective when controlling ventilation in areas with large variations in occupancy

Courtesy: Barker Rinker Seacat Architects

Resources:

Design Share

The International Forum for Innovative Schools
Article: *Indoor Air Quality in Schools: The Importance of Monitoring Carbon Dioxide Levels*

(July 2003)

Website:

www.designshare.com/Research/Sundersingh/IAQ_Monitoring.htm

Environmental Design + Construction

Article: *IAQ Monitoring for Occupant Health*
(November 15, 2004)

Website:

www.edcmag.com/CDA/Archives/cf4fdb719c697010VgnVCM100000f932a8c0

GSA LEED Applications Guide

Guidance on relative cost effectiveness of LEED strategies, including carbon dioxide monitoring.

Website:

www.wbdg.org/ccb/GSAMAN/gsaleeda.pdf

EQ Credit 2: Ventilation Effectiveness

The goal of this credit is to achieve maximum effectiveness of the ventilation provided by optimizing proper air mixing and flow. In other words, the freshest air should be most accessible to the building occupants. Adequate ventilation has been shown to result in higher occupant productivity and satisfaction.

Recommendations:

- This credit requires extensive documentation. Mechanical engineers may require approximately 24 to 40 hours to sufficiently document this credit.
- This credit is most readily achievable with underfloor air distribution or displacement ventilation system.

Helpful Hints:

- This credit is not just about air changes, but also about the *mixing* of the air (airflow).
- Higher ventilation rates do not necessarily correlate with better mixing of the ventilation air. Higher ventilation rates (ach) may reduce the air change effectiveness, because at these higher ventilation rates the residence time (age) of the air is lower and there is less time to mix the air.
- Use ASHRAE 62-2001 guidelines to support the declaration that a project achieves the higher ventilation effectiveness rate.
- Compliance may be demonstrated through performance (testing) or design. In the past there has been confusion as to the documentation requirements to demonstrate compliance. See CIRs (7/19/2004 and others) for further explanation of proper design and calculation procedures.
- Computational Fluid Dynamic calculations and modeling may assist in providing supporting documentation.
- This credit can be achieved using natural ventilation if it is demonstrated that the design provides effective ventilation in at least 90 percent of each room or zone area in the direction of airflow for at least 95 percent of the hours of occupancy. According to the USGBC, “the best way to demonstrate ventilation effectiveness in a naturally ventilated building is to develop a

QUICK FACTS

Implementation: Worth considering.

Historical Data: 36% of Colorado LEED certified projects have successfully earned this credit.



Boulder Community Foothills Hospital

Courtesy: Boulder Associates, Inc

multinodal model of airflow. However, a convincing narrative using demonstrated natural ventilation principles, and including diagrams accurately representing the spaces in question, and supporting calculations based on space characteristics could be used to demonstrate achievement of this credit.”

Examples:

- The Tutt Science Center at Colorado College successfully documented credit compliance by providing data from Titus Electronic Air Management System software showing the isothermal throw data at 150 fpm, 100 fpm, and 50 fpm supply air velocities and air diffusion performance index (ADPI) information.
- Boulder Community Foothills Hospital successfully documented credit compliance (even though it was an overhead distribution system) by providing a design narrative with air diffusion performance index (ADPI) calculations, and a section and plan of each major space showing inlets, outlets, furniture and occupants, with airflow patterns graphically illustrated to scale. In addition, cutsheets and specification tables for all terminal vents, grills and registers

were provided and cross-referenced to the drawings. Finally, an as-built inspection report was developed documenting the system installation, including photographs of each major room type.

Resources:

Referenced Standard: ASHRAE 129-1997:
Measuring Air Change Effectiveness

This standard provides a method for measuring air-change effectiveness in mechanically-ventilated buildings and spaces.

Website: www.ashrae.org

ASHRAE Fundamentals Handbook 2001,
Chapter 32: Space Air Diffusion

This guideline provides descriptions of air diffusion strategies and technologies, methods of evaluation, and system design considerations.

Website: www.ashrae.org

U.S. Department of Energy's Energy Efficiency
and Renewable Energy

Air Handling, Ventilation and Air Quality

This resource includes links to product information, tools, codes and standards.

Website:

www.eere.energy.gov/buildings/info/components/hvac/air.html

Advanced Buildings

Displacement Ventilation

Introduction to how displacement ventilation works, provided by Natural Resources Canada.

Website:

www.advancedbuildings.org/frames/frame_t Vent displ_vent.htm

EQ Credit 3.1: Construction IAQ Management Plan, During Construction

This credit revolves around successful development and implementation of an Indoor Air Quality (IAQ) Management Plan by the general contractor, as outlined in the SMACNA Guidelines for Occupied Buildings Under Construction. Requirements include five control measures that must be documented on three *different* occasions during building construction. These measures, taken by the contractor, help prevent construction activities from negatively affecting the indoor air quality, both during construction and once the building is occupied. Finally, the IAQ Plan should also address the use of MERV 8 filtration media during construction and the replacement thereof with MERV 13 filters prior to occupancy. If the project is also pursuing EQc3.2, the IAQ Plan will also call for either building flush-out or IAQ testing. Ideally, IAQ plan provisions will be cited in the project's specifications for subcontractors to reference as well. It is also a good idea for the general contractors to distribute the IAQ Plan to relevant subcontractors.

Recommendations:

- This credit may not be possible for residential projects with smaller air handling units, as small units may not be able to handle the required MERV 13 filters.
- Mechanical engineers have pointed out that the installation of high efficiency filters may increase fan energy and, therefore, can detract from overall building energy efficiency. The project team should evaluate this credit early in the design process.

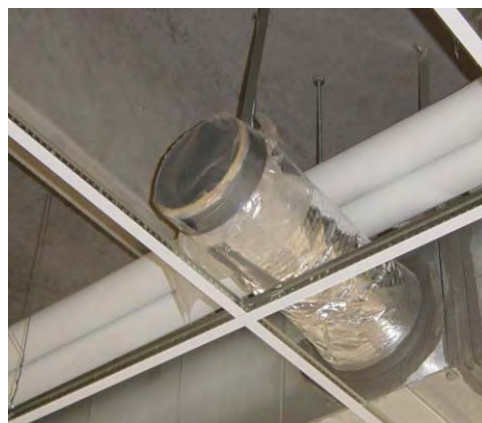
Helpful Hints:

- Pictures! Pictures! Pictures! Assign the responsible party for documenting how the project is following the five SMACNA approaches early in construction. As LEED requires these photos from three different occasions in the project, it is not possible to take all of them at the end of the project. Captions of each SMACNA approach identified should be included.
- Creating the IAQ Plan before construction begins will ensure adequately addressing all SMACNA approaches. Specification language should be included where possible.

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 71% of Colorado LEED certified projects have successfully earned this credit.



US Department of Transportation
HVAC Protection During Construction
Courtesy: Opus Northwest

- The required control measures are generally standard construction practices in such facilities as hospitals or laboratories where high indoor environmental air quality is important.

Examples:

- To earn LEED credit, the Belmar Block 2 development project provided an excerpt from the Tenant Criteria Manual documenting specific guidelines for tenant construction IAQ management consistent with the documented core and shell build-out performance.
- On the Tutt Science Center at Colorado College, the mechanical system was not used during construction. MERV 8 filters were not required but installation of MERV 13 filters were required prior to occupancy to earn credit.

Resources:

Referenced Standard: Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, 1995, Chapter 3
Website: www.smacna.org

Chelsea Group, Ltd.
LEED- Maintaining Indoor Air Quality During Construction
Highlights solutions to achieve EQc3
Website: 66.155.72.72/newsletter/BDXLEED-Maintaining%20Indoor%20Air%20Quality%20During%20Construction.pdf

Resource Venture
Construction IAQ for LEED 2.1 in Seattle
Includes resources, cost, guidelines and practices required to achieve the credit. Applicable to all locations, not just Seattle.
Website: www.resourceventure.org/rv/publications/building/LEED-IAQ.pdf

EQ Credit 3.2: Construction IAQ Management Plan, Before Occupancy

This credit can be earned independently of EQc3.1 and requires either conducting a building flush-out, post-construction and prior to occupancy, or contracting an independent Indoor Air Quality Test. Note that performing a two-week building flush-out grants award of the LEED credit, but adds two weeks to the construction schedule. Performing an Indoor Air Quality Test adds a day to the construction schedule, but earns LEED credit *only* if test results demonstrate that the air quality passes the required standard.

Recommendations:

- If the flush-out option is chosen, revise the construction project schedule to include the appropriate two-week milestones.
- If IAQ testing is chosen, determine if the associated cost will be a contractor's or owner's contingency.

Helpful Hints:

- Some projects include both flush-out and testing options in the specifications and allow the construction schedule to dictate whether the two-week building flush-out is feasible. Alternatively, if the schedule does not permit, IAQ testing is already in the project budget.
- New MERV 13 filtration equipment must be installed prior to and after the flush-out.
- It is possible to stage the flushing of a building if areas are separated physically and the mechanical systems can operate separately. Once the area has been flushed out, however, it is necessary to maintain separation from areas under construction per SMACNA Guidelines for Occupied Buildings.
- If IAQ testing is chosen, quality control in the field will be more stringent due to strict LEED requirements about what can and cannot be present during testing (furniture, etc.). See the many CIRs that address this issue.
- If the flush-out procedure is performed the project team should carefully address the following issues:

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 71% of Colorado LEED certified projects have successfully earned this credit.

1. Allowable work during the flush-out period:
 - Punch-list items are part of construction and must be completed prior to building flush out.
 - Commissioning is not part of construction and, as long as the process of commissioning does not introduce any additional contaminants into the building, commissioning activities may occur during flush out.
 - Moving items into the building such as furniture may add a chemical sink to the interior of the building.
 - Occupant training and installation of security systems etc. is acceptable during flush-out.
 - "LEED-NC prefers, but does not require, the flush to occur before furniture installation." (CIR 3/17/05)
2. Owner move-in times and dates must take place after the flush-out.

Example:

- A large majority, if not all, LEED certified projects in Colorado that have achieved this credit have done so by performing the two week building flush-out rather than performing the IAQ testing.

EQ Credit 4: Low-Emitting Materials

EQ credits 4.1 through 4.4 target the primary source of contaminants that contribute to poor indoor air quality in a building. The goal is to reduce or eliminate the introduction of harmful chemicals through the proper selection of building materials on the project, by minimizing volatile organic compounds (VOCs). With the exception of EQc4.4, these credits can all be achieved at no additional cost. In recent years, material suppliers and manufacturers have become particularly savvy to LEED requirements and the documentation required to identify low-VOC products is readily available. Note that EQ credits 4.1-4.4 are applicable to interior materials only. The USGBC defines interior products as “products inside the exterior moisture protection.” Furniture, fit-out, equipment, exterior paints, or any shop-applied or finish applied off-site prior to installation are not subject to credit requirements.

General Recommendations:

- Since these credits pertain to multiple building materials, it is critical that compliance is specified in the project specifications. Ideally, the material specification requirements will be repeated in each applicable division so that the subcontractors who only read their relevant section will still be made aware of the requirements.
- The general contractor should review all relevant product submittals and oversee all subcontractor activities on-site to avoid mistaken non-compliant product substitutions.
- Document, document, document! Several LEED document submittals have been delayed because of difficulty getting documentation from the contractor. It is much more difficult to go back and dig up records after the project is built than at the time of construction submittals.

Helpful Hints:

- In general, these credits require 100 percent compliance. However, an alternative compliance path is available, if necessary. A project can complete a “VOC Budget”, if use of a *minimal* amount of a high-VOC product is unavoidable. This calculation procedure demonstrates the project’s actual overall VOC level for paints *or* adhesives is

less than the permissible total threshold for low-VOC products on the project. This may be necessary if the USGBC rules a paint or adhesive non-compliant during their preliminary review.

- Consider potential Innovation in Design credits relating to low-emitting materials such as:
 1. Low-VOC interior furnishings.
 2. Exterior paints and stains.
- The USGBC has not clearly specified a minimum requirement regarding product quantity for these credits. Thus, a project could potentially request LEED credit EQc4.3 for using one square foot of low-admitting carpet in a building with all concrete floors. It is up to the project team to be reasonable in their application for these credits.

Resources:

Scientific Certification Systems, Inc.

Scientific Certification Systems, Inc. has released an Indoor Air Quality Performance certification program for interior products. The program is designed to demonstrate product conformance with the indoor emissions limits associated with California’s Section 01350 specification, as well as emission criteria in the LEED Rating System and international standards for environmental labeling.

Website: www.scscertified.com/iaq/

GreenGuard Environmental Institute

Product Guide

Provides a searchable database for low-emitting materials

Website:

www.greenguard.org/DesktopDefault.aspx?tabid=12

California High Performance Schools (CHPS)

CHPS has drafted a “compliant materials table” that lists materials that have low VOC values. This table can be used as a resource to find many material manufacturers from adhesives to building insulation.

Website: www.chps.net/manual/lem_table.htm

EQ Credit 4.1: Low-Emitting Materials, Adhesives & Sealants

See EQ Credit 4 for general information on the Low-Emitting Materials credits.

Recommendation:

- This credit is not difficult, but does require diligent documentation by the general contractor.

Helpful Hints:

- This credit applies to Divisions 2-16. Don't forget about plumbing, HVAC (duct sealants) and fire caulking when tracking for this credit.
- Some industrial-grade adhesives and sealants are difficult to find with low VOCs.

Examples:

- The USGBC questioned two products in the preliminary review of Fossil Ridge High School adhesives and sealant submittal, but the project team was able to provide additional information demonstrating the materials were specialty coatings that complied with applicable VOC standards.
- The Belmar Block 2 development project provided an excerpt from the tenant guidelines outlining the recommendations are consistent with building core and shell performance.
- Colorado Department of Labor & Employment employees were pleasantly surprised that the new addition had 'no new building smell', due to the attention to low-VOC adhesives, paints and carpets.

Resources:

Adhesives Referenced Standard: VOC limits of South Coast Air Quality Management District Rule #1168

Website:

www.aqmd.gov/rules/reg/reg11/r1168.pdf

Sealants Referenced Standard: Bay Area Air Quality Management District Reg. 8, Rule 51

Website:

www.baaqmd.gov/dst/regulations/rg0851.pdf

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 100 % of Colorado LEED certified projects have successfully earned this credit.



Colorado Springs Utilities Laboratory

Protects air quality in the laboratory atmosphere, and achieved all four low-emitting materials credits.

Courtesy: Ed LaCasse Photography

EQ Credit 4.2: Low-Emitting Materials, Paints

See EQ Credit 4 for general information on the Low-Emitting Materials credits.

Recommendation:

- This credit is not difficult, but does require diligent documentation by the general contractor.

Helpful Hints:

- The LEED requirements apply only to opaque top-coat, interior paints. Stains and transparent finishes are outside of the LEED scope.
- Interior materials that are painted off-site do not count for this credit; however, even materials painted off-site are recommended to be low-VOC compliant, especially if IAQ testing is planned (EQc3.2).
- Some industrial-grade paints are difficult to find with low VOCs.
- Low-VOC black paint, although becoming more available, is particularly hard to find. In this instance, consider the use of black dry-fall, a spray application that dries to a dust before reaching the floor.

Examples:

- Belmar Block 2 prepared a VOC budget when the preliminary USGBC review initially rejected the credit stating that one paint did not meet the standard. Because the non-compliant paint was used on a small area, the “VOC Budget” demonstrated compliance and the project was awarded the point.

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 79% of Colorado LEED certified projects have successfully earned this credit.



Boulder Community Foothills Hospital
Low-VOC interior paints contribute to superior indoor air quality to promote health
Courtesy: Boulder Associates, Inc.

Resources:

Green Seal

Provides product standards and certification for paints and coatings.

Website:

www.greenseal.org/certproducts.htm#paints

Toolbase Services

Low or No VOC Paints

Includes benefits, costs, and resources.

Website:

www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1312&DocumentID=2174

EQ Credit 4.3: Low-Emitting Materials, Carpet

See EQ Credit 4 for general information on the Low-Emitting Materials credits.

Recommendation:

- While this credit requires diligent documentation from the contractor, it is one of the most easily achievable of all the LEED credits, due to the market availability of low-emitting carpets.

Helpful Hints:

- This credit will have synergies with EQc4.1 (adhesives & sealants) for carpet adhesive.
- Don't forget, this credit applies to the entire carpet system - carpet fiber, carpet backing and the carpet padding. Manufacturer's documentation can be misleading; make sure the entire carpet system will meet the Carpet and Rug Institute's standards required by this credit.

Resources:

Building Green

Article: *Carpeting, Indoor Air Quality & The Environment*

Website:

www.buildinggreen.com/features/crpt/carpets.cfm

Carpet and Rug Institute (CRI)

Certifies products that meet or exceed the CRI's Indoor Air Quality Testing requirements.

Website: www.carpet-rug.org/index.cfm#

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 100% of Colorado LEED certified projects have successfully earned this credit.



CH2M HILL

Low-VOC carpet minimizes air pollutants

Courtesy: CH2M HILL

EQ Credit 4.4: Low-Emitting Materials, Composite Wood

See EQ Credit 4 for general information on the Low-Emitting Materials credits.

Recommendations:

- While many Front Range suppliers can provide urea-formaldehyde free composite wood at no extra cost, high demands have created long lead times for this type of wood, in some cases. Confirm this credit and the scope early in project design so long lead times will not hinder the construction schedule.
- This credit can be forfeited late in construction by a careless on-site substitution of non-compliant composite wood products. Subcontractors should be made aware that all last minute runs to the lumber yard are subject to the same urea-formaldehyde free requirements as the rest of the project.

Helpful Hints:

- Plywood, particleboard, OSB, MDF, strawboard, wheatboard, and similar products are all composite wood and agrifiber products subject to the credit requirements. Note that composite wood components used in assemblies are also controlled. Don't forget the following composite wood products:
 - Door cores
 - Telephone backerboard
 - Millwork
 - Backing on wall pads in gymnasiums
 - Plywood sections of I-beams

Examples:

- Aspen Skiing Company's Snowmass Golf Clubhouse used formaldehyde-free strawboard cabinets.
- Boulder Community Foothills Hospital and Colorado Department of Labor & Employment, both initially pursued this credit. In both cases, the projects were unsuccessful because the encased particleboard core of the "solid core" wood doors used was not urea formaldehyde-free.

QUICK FACTS

Implementation: Recommended.

Historical Data: 29% of Colorado LEED certified projects have successfully earned this credit.



Snowmass Golf Clubhouse
Courtesy: Aspen Skiing Company

Resources:

Advanced Buildings Technologies and Practices Formaldehyde-Free MDF

This fact sheet gives a brief description of formaldehyde-free MDF including, applications, cost and example manufacturers with contact information.

Website:

www.advancedbuildings.org/main_t_finishes_formaldehyde.htm

EQ Credit 5: Indoor Chemical & Pollutant Source Control

This credit intends to minimize occupant exposure to indoor air pollutants, including particulate matter entering the building from foot traffic at entryways, liquid chemical waste and chemical use from copy rooms and janitorial/housekeeping rooms. These three pollutant sources are mitigated through use of permanent entry mats, full-height walls and separate outside exhaust at copy and janitor rooms, and proper plumbing for disposal of liquid chemical waste.

Recommendations:

- Identify possible pollution sources related to this credit early in design. This will help to prevent expensive change orders for exhaust fans, pocket doors or other elements needed to revise the building design to meet the credit requirements.
- Call out walk-off mats and label relevant drains and deck-to-deck partitions on project drawings.

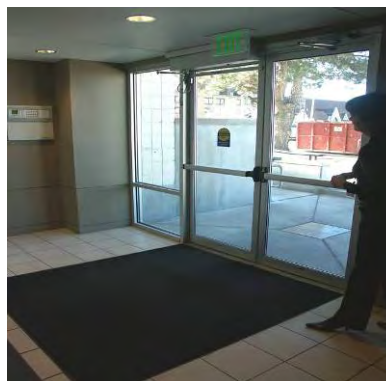
Helpful Hints:

- Credit requirements are readily included in the project design and most codes include requirements for plumbing where chemical use occurs.
- Residential or dormitory units with separate, exterior entrances must have permanent entry mats. However, if the units share one exterior entrance, only central entry walk-off mats will be required. According to the USGBC, “any door that is intended to be used regularly and frequently by building occupants should be considered high volume for the purposes of this credit.”
- Small, low-volume copiers are not considered pollutant sources and do not require full height partition walls under this credit. The USGBC leaves the definition of a convenience copier or printer to the discretion of the design team, but states that they are generally the smaller printers and copiers shared by many office personnel for short print and copy jobs. Include a narrative in the LEED submittal describing the use and location of these low-volume copiers and why they are exempt from the LEED requirements.

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 79% of Colorado LEED certified projects have successfully earned this credit.



Colorado Dept. of Labor & Employment

Inset interior walk-off mats minimize the introduction of outdoor pollutants at entryways

Courtesy: Colorado Department of Labor & Employment

Example:

- Fossil Ridge High School successfully earned this credit by providing documentation indicating the location of installed entryway walk-off mats, room separations and required ventilation supported by annotated building plans, cut sheets, contractor submittals and mechanical details.

Resources:

Colorado Department of Public Health & Environment, Indoor Air Quality

Lists local IAQ consultants and resources.

Website: www.cdphe.state.co.us/ap/IAQhom.asp

California, Division of the State Architect

Article: *Sustainable Schools- Indoor Environmental Quality*

Website:

www.sustainableschools.dgs.ca.gov/SustainableSchools/sustainabledesign/ieq/iaq/pollutantsourcecontrol.html

EQ Credit 6.1: Controllability of Systems, Perimeter

Two systems must be provided to achieve this credit: operable windows and lighting controls for all regularly occupied, perimeter spaces. Providing the sufficient number of operable windows is generally the more difficult (and expensive) design challenge. Designs that include enclosed perimeter offices typically provide sufficient lighting controls to meet the credit based on the square footage of the layout. In designs with open offices or other multi-occupant settings (gymnasiums, classrooms etc.), LEED requires a group multi-occupant space calculation be performed. In such cases, it is generally possible to meet the lighting control requirements through proper design of on/off switches, occupancy sensors, daylight sensors, etc. The number of operable windows required, however, is always based on square footage requirements regardless of the distribution of occupants within the occupied spaces (approximately one window every 13 linear feet along the perimeter.) Although the majority of building occupants consider operable windows highly desirable, operable windows are not common design practice in commercial buildings. Reasons include security, safety, maintenance and mechanical system stability.

Recommendations:

- Consider and discuss operable windows early in design to determine if they are an appropriate and viable design option for the project type.
- Reference the group multi-occupant calculation methodology in the LEED Reference Guide to determine required number of lighting controls for rooms such as conference rooms, open office area, etc.
- Review drawings carefully as the design develops to ensure the required number of operable windows and lighting controls are provided and documented.

Helpful Hints:

- For the purposes of this credit, the USGBC defines “regularly occupied” as: if in the course of a regular daily experience users could be expected to find themselves in the space. However, support areas for copying, storage, mechanical equipment, laundry, and restrooms should be excluded from the calculation.

QUICK FACTS

Implementation: Worth considering.

Historical Data: 14% of Colorado LEED certified projects have successfully earned this credit.



Colorado College Tutt Science Center

Courtesy: Colorado College

- If 75 percent or more of a room is within 15 feet of the perimeter wall, the area of the entire room should be classified as perimeter area.
- Lighting controls in residences are generally considered to be individually controlled and meet the intent of this credit.
- Task lighting may be applied to this credit (as an additional lighting control), only if it is hardwired.
- LEED does not exempt laboratory or retail spaces from the operable window requirement. For such cases, transom windows may be an option.

Examples:

- The Tutt Science Center and Snowmass Golf Clubhouse are the only certified projects to date that have achieved this credit in Colorado.
- Although Boulder Community Foothills Hospital did not attempt this credit, operable windows equipped with contact switches connected to the room’s VAV box were installed in each patient room. This allowed the mechanical system to damper down to a minimum supply in spaces where the windows were open.

Resources:The Center for the Built Environment (CBE)

The CBE at the University of California, Berkeley is a National Science Foundation Industry/University Cooperative Research Center. This website includes extensive research on occupant indoor environmental quality issues including operable window studies.

Website: www.cbe.berkeley.edu/

American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

ASHRAE has many articles publications with regard to occupant comfort and individually controlled spaces. (Search for “occupant comfort”, “controllability”, “individual control”)

Website: www.ashrae.org

U.S. Department of Energy

Article: *Health and Productivity Gains from Better Indoor Environments and Their Implications for the U.S. Department of Energy*, Summarizes numerous studies that show productivity increases due to improved indoor environments. (2000)

Website: eetd.lbl.gov/IED/viaq/pubs/LBNL-47458.pdf

See Appendix D for additional resources on the benefits of high performance design.

Starting a new LEED-NC project?

All new LEED-NC projects will register under version 2.2 (as of January 2006). Refer to the USGBC for complete information about version 2.2. Also, see Appendix C of this Guide for a quick overview of the changes from version 2.1 to 2.2.

EQ Credit 6.2: Controllability of Systems, Non-Perimeter

Three systems must be provided in all regularly occupied non-perimeter spaces to earn this credit: temperature controls, airflow controls and lighting controls. The number of controls required to earn credit is not based on square footage. Instead, the requirements are all based on providing controls for 50 percent (one out of two people) of the occupants in each interior space. Interior spaces are defined as spaces that are at least 15 feet from the outer wall of the building. Providing the required number of lighting controls is typically not an issue. Occupancy sensors, daylighting controls, dimming switches and manual automatic on/off switches can all be counted as two lighting controls and the group multi-occupant calculation methodology applies (see LEED Reference Guide). The lighting designer or electrical engineer should perform preliminary calculations early in the design to confirm the credit requirements are being met.

The focus for this credit is generally on airflow and temperature controls. Depending on the type of system, this credit might be easily achieved. For example, in an office building with interior offices and a VAV distribution system, this credit is achieved by providing one VAV box for every two offices. However, this credit may be costly or increase energy use if additional mechanical zones and associated air distribution units are added merely to attain the credit. (This credit frequently requires multi-zones in multi-occupant spaces.) In some cases, the same device may provide temperature and airflow controls. For example, an adjustable underfloor air diffuser or a thermostat controlling a VAV box may be considered both a temperature and airflow control. As with the lighting controls, the mechanical engineer should perform preliminary calculations to determine if the number of airflow and temperature controls will meet the credit requirements.

Recommendations:

- Review credit requirements and do preliminary calculations to determine if the design is meeting the requirements or if temperature, airflow and lighting controls need to be added to achieve the credit.

QUICK FACTS

Implementation: Worth considering.

Historical Data: 0% of Colorado LEED certified projects have successfully earned this credit.

- Review drawings early in design to ensure they show the appropriate number of temperature, airflow and lighting controls.

Helpful Hints:

- Reference the group multi-occupant calculation methodology in the LEED Reference Guide for rooms such as conference rooms, open office area, etc.
- The control strategies can't rely on average temperature inputs, individual temperature control must be provided.
- Check CIRs if there are questions regarding a certain control device serving as both a temperature and airflow control.

Examples:

- North Boulder Recreation Center attempted to achieve this credit. Preliminary review stated that sufficient controls must be provided for 50 percent of the occupants themselves, not 50 percent of occupied spaces. Final review showed that the required ratio of 1:1:2 for terminal box to controller to occupant was not achieved.

EQ Credit 7.1: Thermal Comfort, Comply with ASHRAE 55-1992

This credit promotes optimal occupant comfort through temperature and humidity control. For mechanically ventilated space, EQc7.1 requires meeting the ASHRAE Standard 55-1992 for thermal comfort standards, and for naturally ventilated spaces the project must comply with the 90 percent acceptability limits of the adaptive comfort temperature boundaries in the Collaborative for High Performance Schools (CHPS).

LEED recently adopted the ASHRAE 55-2004 standard, which eliminates the lower humidity limit. This has significant implications for projects in Colorado's dry climate, since it eliminates the need to install humidification systems to meet the requirement.

Recommendation:

- Since humidification is no longer required by ASHRAE in Colorado's dry climate, most standard mechanical designs now meet the requirements of this credit.
- Engineers should confirm that the project meets the minimum requirements of ASHRAE 55-1992 upfront and early in design.

Helpful Hints:

- Psychometric analysis or output from a building energy model can be used to demonstrate that a building meets ASHRAE Standard 55 for 98 percent of the time that the building is occupied.
- An example of information sufficient to demonstrate compliance includes:
 - a. Initial Design Criteria - Outdoor Ambient Design Conditions and Indoor Design Conditions.
 - b. Initial assumptions for thermal comfort with regard to climate, activity level, clothing, etc. per referenced ASHRAE 55 standard.
 - c. Air movement ranges for each air handler.

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 71% of Colorado LEED certified projects have successfully earned this credit.



University of Denver Ricketson Law Building
Courtesy: H+L Architecture

Examples:

- Several projects in Colorado successfully earned this credit by providing the following documentation for their project: a LEED Letter Template declaring that the project has been designed to maintain indoor comfort within ranges established in ASHRAE Standard 55-1992, Addenda 1995, a table listing control ranges and installed control methods, and psychometric analysis charts.

Resources:

Referenced Standard: ASHRAE 55-1992:
Thermal Environmental Conditions for Human
Occupancy

ASHRAE 55-1992, Addenda 1995 is the energy
standard referenced by the LEED-NC v2.1
Reference Guide.

Website: www.ashrae.org

Referenced Standard: California High
Performance Schools (CHPS) Best Practices
Manual, Appendix C – A Field Based Thermal
Comfort Standard for Naturally Ventilated
Buildings, Figure 2.

Website: www.chps.net

USGBC

The USGBC has accepted ASHRAE Standard
55-2004 as an alternative compliance Referenced
Standard in a Credit Interpretation Ruling dated
9/8/2004. In Colorado and other arid regions,
this is advantageous because the new ASHRAE
standard does not give a recommended lower
humidity limit.

Website: www.usgbc.org/

Whole Building Design Guide

The whole building design guide is a
comprehensive resource for the building
industry. It includes cost studies, design
guidance, references, case studies and much
more.

Website: www.wbdg.org/

EQ Credit 7.2: Thermal Comfort, Permanent Monitoring System

While the previous credit requires that thermal comfort be maintained, this credit requires that temperature and humidity conditions be monitored and controlled through a permanently installed monitoring system. Like EQc7.1, this credit has become more readily achievable since humidification is no longer required for projects in Colorado.

Recommendations:

- Temperature and humidity monitoring and control system design is largely left to the discretion of the mechanical engineer and commissioning agent. Evaluate EQc7.1 and EQc7.2 early in the design process to establish credit viability.
- Projects have successfully designed adequate monitoring and control systems based on the mechanical engineer's and commissioning agent's recommendations. Documentation should include a narrative describing how the measurement points and operator interface, as designed, comply with the credit requirements.

Helpful Hints:

- In general, the project needs to demonstrate that humidity is controlled, or demonstrate through modeling/analysis that humidity control will not be necessary to maintain comfort.
- Monitoring systems (thermostats and humidistats) are required regardless of whether humidification/dehumidification control systems are required. However, humidity sensors can be used in place of humidistats if humidification control systems are not provided.
- Monitoring systems are required to be tested as part of the EAp1 Fundamental Building Systems Commissioning scope of work.

Example:

- North Boulder Recreation Center achieved this credit using a system that connected temperature and humidity sensors to the buildings Direct Digital Control (DDC) system.

QUICK FACTS

Implementation: Worth considering.

Historical Data: 36% of Colorado LEED certified projects have successfully earned this credit.

EQ Credit 8.1: Daylight & Views, Daylight 75% of Spaces

EQ Credits 8.1 and 8.2 examine the availability of daylight and access to views in the building. EQc8.1 requires 75 percent of the regularly occupied spaces achieve a minimum two percent Daylight Factor. The Daylight Factor is defined as the ratio of interior horizontal illuminance to exterior horizontal illuminance. This credit can be documented with the use of daylight modeling software or equations (and spreadsheets) supplied by the USGBC. Colorado's sunny climate offers many excellent opportunities for aggressive daylight harvesting, making this an attractive credit to pursue for nearly all types of projects.

Recommendation:

- Use of effective solar control strategies (overhangs) and high performance glazings are highly recommended to limit associated solar gains. Achieving the daylight credit is likely to contribute to increased energy savings in the Energy and Atmosphere credits. This is largely due to savings in the electrical lighting that result from well daylight spaces.

Helpful Hints:

- The USGBC calculation methods (requiring a two percent Daylight Factor) can require prohibitively high interior illuminance levels in climates with high exterior illuminance levels, like Colorado. The USGBC has ruled that if computer modeling can demonstrate that 25 horizontal footcandles are provided under clear sky conditions, at noon, on the equinox, at 30 inches above the floor, the credit is achieved. This alternative calculation method makes the credit considerably more accessible.
- EQc8.1 excludes spaces where tasks would be hindered by the use of daylight, e.g., photography dark rooms and x-ray viewing rooms.
- Daylight glazing (above 7'-6") offers the most benefit for harvesting daylight deeper into the space (although they do not count towards EQc8.2).
- This credit may have synergies with the lighting control strategies required in EQc6.1 and EQc6.2.

QUICK FACTS

Implementation: Worth considering.

Historical Data: 14% of Colorado LEED certified projects have successfully earned this credit.



Fossil Ridge High School Media Center

Courtesy: RB+B Architects

Examples:

- Although Fossil Ridge High School is very well daylight, the project did not achieve this credit because it did not have a 2 percent Daylight Factor. While the credit was not achieved, the careful daylighting design of the high school provides a pleasant atmosphere, much of the energy savings for the building, and an environment designed to promote learning.
- Projects that have achieved this credit in the past have successfully delineated spaces where daylight would hinder required tasks, therefore exempting the spaces from the calculation.

Resources:**Collaborative for High Performance Schools (CHPS)**

CHPS provides an array of free resources for school districts and designers, including best practices manuals, fact sheets on daylighting and other strategies, and a list of low-emitting materials.

Website: www.chps.net

Lawrence Berkley Laboratories

Daylight in Buildings: A Source Book on Daylighting Systems and Components Lawrence Berkley Laboratories, A report of IEA SHC Task 21/ ECBCS Annex 29 (July 2000)

Website: gaia.lbl.gov/iea21/ieadownload.htm

Heschong Mahone Group***Daylighting Productivity Studies***

This firm has performed a variety of productivity studies measuring the impact of daylighting on retail sales and student performance. Test results showed students in rooms with daylighting learned quicker than those in non-daylit rooms. Poudre School District was one of the districts included in this study.

Website: www.h-m-g.com/projects/daylighting/projects-PIER.htm

Daylight Dividends

A collaboration of the U.S. Department of Energy, Lighting Research Center and others is working to document productivity improvements and other benefits of daylighting. Find a variety of case studies and research at this website, hosted by Rensselaer Polytechnic Institute www.lrc.rpi.edu/programs/daylighting/index.asp

EQ Credit 8.2: Daylight & Views, Views for 90% of Spaces

This credit requires 90 percent of regularly occupied spaces achieve a direct line of sight to vision glazing. Vision glazing, as defined by the USGBC, includes windows located between 2'-6" and 7'-6" above the floor. Therefore, skylights or clerestory windows cannot be included in the calculations. Building orientation and floor plate size and layout should all be considered to improve access to daylight and views. For example, a square building with a large floor plate may have difficulty achieving either of the daylight credits because of the distance between core building spaces to the perimeter glazing. A long, narrow building makes it easier to situate regularly occupied spaces adjacent to the perimeter. It is beneficial to locate spaces with open layouts (i.e. open offices) near the perimeter, and circulation and support spaces near the core to help deliver daylight and views to the spaces that benefit from it most.

Recommendation:

- The views credit is achievable with simple yet important design decisions made early in the project, such as footprint shape and space layout. A building that provides sufficient views to the outside will maintain healthier and happier building occupants.

Helpful Hints:

- Design the building floorplate so that as many regularly occupied spaces as possible are located near the perimeter, with access to glazing. Open offices should be located at the perimeter with enclosed spaces and support areas near the building core.
- Glazing should be shaded appropriately to control solar heat gains in Colorado's sunny climate.
- Include interior transom glazing to add views to enclosed spaces away from the perimeter of the building.

Examples:

- North Boulder Recreation Center was able to earn this credit by adding a view window in the large gymnasium space.
- The GSA Department of Transportation project was able to provide views to the exterior from 91 percent of the regularly occupied interior spaces.

QUICK FACTS

Implementation: Strongly recommended.

Historical Data: 57% of Colorado LEED certified projects have successfully earned this credit.



US Department of Transportation

Courtesy: Opus Northwest



Colorado Department of Labor & Employment

Courtesy: Colorado Department of Labor & Employment

- In the Colorado Department of Labor & Employment addition, unemployment claims call center staff work areas were positioned near windows. This provides mountain and city views for employees who are on the telephone most of the day.